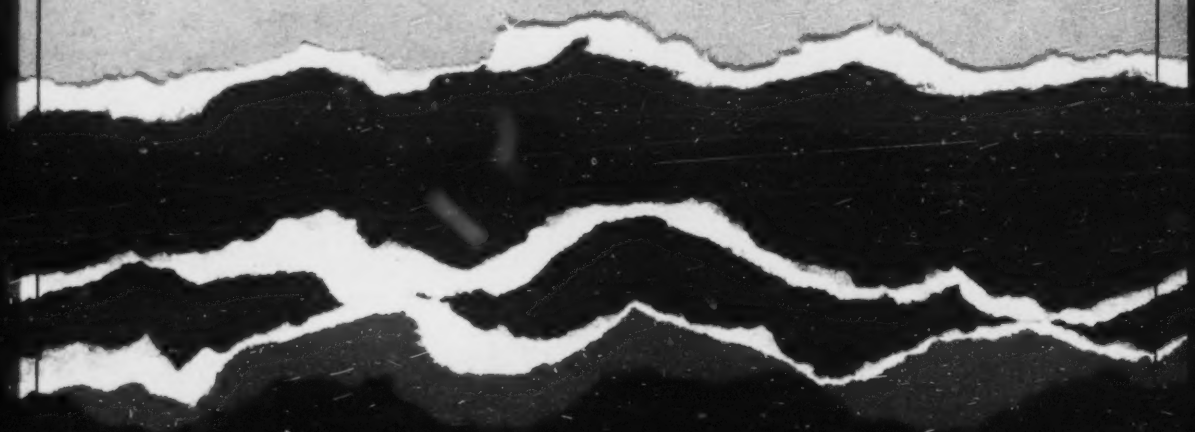
# Ocean Incineration:

## Its Role in Managing Hazardous Waste



## Summary

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# Foreword

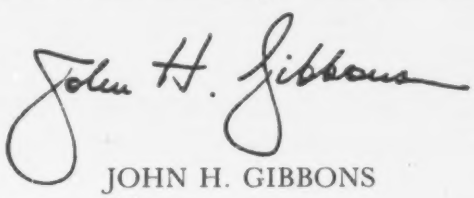
The American approach to managing hazardous wastes is undergoing rapid change. A decade ago Congress passed the Resource Conservation and Recovery Act (RCRA), formally recognizing the costs of past, indiscriminate land disposal. The Nation now is moving with some urgency toward development and greater utilization of methods that destroy, treat, recycle, or reduce the generation of hazardous wastes.

Within this context of change, one of the many distinct technologies for managing hazardous wastes—ocean incineration—has received an extraordinary degree of attention. Is ocean incineration part of the solution to, or simply a repetition of, the mistakes of the past? By burning hazardous wastes far from land, are we reducing risks to human health or simply shipping our problems out to sea? Is the small but real risk of a catastrophic spill worth the benefit of actually destroying most of the wastes?

In 1984, two congressional committees—the House Committees on Merchant Marine and Fisheries and on Public Works and Transportation—requested the Office of Technology Assessment to undertake a broad study of wastes in marine environments, including an examination of ocean incineration. At that time, the Senate Committee on Commerce, Science, and Transportation endorsed the study. More recently, the original requesting committees and the House Committee on Science and Technology asked OTA to prepare a full report on ocean incineration. In response to the latter request, this assessment, *Ocean Incineration: Its Role in Managing Hazardous Waste,* provides a comprehensive examination of ocean incineration technology. A second assessment responding to the initial request is in preparation.

This assessment of ocean incineration includes consideration of the adequacy of regulations; risks to human health and the marine environment relative to the risks of comparable activities; existing and emerging alternatives; the capabilities and limitations of ocean incineration in managing hazardous wastes; and how its use might affect efforts to develop superior waste treatment and reduction practices. Particular attention is addressed to areas of intense public concern over the use of this technology. This report is offered to aid Congress in its deliberation of the fate and design of the ocean incineration program.

Many individuals in government, industry, the public interest and environmental communities, and academia contributed to the effort represented by this report. In particular, OTA wishes to thank the advisory panel and the many reviewers who devoted time and energy to this undertaking.



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NOTE: OTA appreciates and is grateful for the valuable assistance and thoughtful critiques provided by the advisory panel members. The panel does not, however, necessarily approve, disapprove, or endorse this report. OTA assumes full responsibility for the report and the accuracy of its contents.

### Related OTA Reports

- *Wastes in Marine Environments.* In preparation.
- *Serious Reduction of Hazardous Waste for Pollution Prevention and Industrial Efficiency. In press.*
- *Transportation of Hazardous Materials.* OTA-SET-304; July 1986. GPO stock #052-003-01042-9; $13.00.
- *Superfund Strategy.* OTA-ITE-252; April 1985. GPO stock #052-003-00994-3; $10.00.
- *Protecting the Nation's Groundwater From Contamination.* OTA-O-233; October 1984. GPO stock #052-003-00966-8; $7.50.
- *Acid Rain and Transported Air Pollutants: Implications for Public Policy.* OTA-O-204; June 1984. GPO stock #052-003-00956-1; $9.50
- *Technologies and Management Strategies for Hazardous Waste Control.* OTA-M-196; March 1983. NTIS order #PB 83-189 241.

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# Ocean Incineration: Its Role in Managing Hazardous Waste

## OVERVIEW

Few practices, even in the tumultuous arena of hazardous waste management, have engendered as much controversy and polarization as has the concept of burning hazardous wastes in incinerators mounted on ocean-going vessels. Critics have characterized ocean incineration vessels as "outmoded, unforgiving technology" and "nothing more than old-fashioned pot-bellied stoves without the smokestack," whereas proponents see ocean incineration as "a way to prevent the cancer that chemicals may cause" and "to destroy hazardous wastes before they destroy us." When the U.S. Environmental Protection Agency (EPA) held a public hearing on ocean incineration in Brownsville, Texas, in 1983, more than 6,000 people attended, which vividly demonstrates the level of public concern over this technology.[1] Such concerns have temporarily halted the development of ocean incineration in this country.

The debate over ocean incineration reflects the tenor of change taking place in the American approach to managing hazardous waste. The Hazardous and Solid Waste Amendments of 1984, which amended the Resource Conservation and Recovery Act (RCRA), responded to the growing recognition that the methods used in the past to dispose of hazardous wastes should no longer be used. Mounting evidence of groundwater contamination and other problems associated with leakage of wastes from the growing list of Superfund sites lent a new sense of urgency to finding new approaches. To replace the old practices, Congress has called for the development of environmentally sound methods for disposing of, treating, destroying, and recycling hazardous wastes, and for reducing their generation. It is against this background of transition that Congress must decide what role, if any, ocean incineration should play in managing America's hazardous wastes.

Existing and developing methods for managing hazardous wastes are commonly organized into a hierarchy that accords preferred status to methods that reduce *risk* by reducing the quantity and degree of hazard of wastes.

The highest tier in the hierarchy includes those methods—collectively referred to as waste reduction—that actually avoid the generation of wastes.[2] Disposal practices that attempt to contain waste or actually disperse them in the environment occupy the lowest tier. Between these tiers are those methods—distinct from disposal practices—that reduce risks by recovering, treating, or destroying wastes after they are generated. For example, a prop-

[1]This public hearing was the largest in EPA's history. At issue was whether to grant a permit for incinerating PCB- and DDT-containing wastes at an ocean site in the Gulf of Mexico.

[2]Not all practices that are commonly considered waste reduction actually lead to *risk* reduction. For example, process modifications can reduce the *quantity* of waste or alter its composition without necessarily reducing the *degree of hazard* of any resulting waste. As used in this assessment, however, the term waste reduction refers only to environmentally sound practices that actually accomplish *risk* reduction.

erly operating incinerator can destroy more than 99 percent of certain hazardous wastes, greatly reducing both their quantity and degree of hazard.[3]

In such a hierarchy, the technology of ocean incineration falls midway between most disposal practices, which are generally inferior, and most reduction, recycling, and advanced treatment technologies, which are generally superior. For what hazardous wastes could ocean incineration be used? Of all hazardous wastes, only a fraction (up to 20 percent) is amenable to incineration. Of these *incinerable* wastes, only those in *liquid* form (up to about 8 percent of all hazardous wastes) could be incinerated at sea. For liquid wastes that are *highly chlorinated,* several technical factors constrain the ability of available land-based alternatives to effectively manage such wastes. Because these limitations do not apply to ocean incineration, it is one of only a few technologies available to manage highly chlorinated wastes.

**The fundamental choice that must be faced is whether to develop an ocean incineration program.** This decision must consider a variety of factors, both technical and nontechnical. Because no methods are risk-free, the risks that ocean incineration poses—to human health and the marine environment—and the benefits that it provides—by actually destroying most of the wastes—must be weighed against those of the land disposal practices and other treatment methods that are currently used for liquid incinerable wastes.

**OTA finds that ocean incineration could be an attractive, though not essential, interim option for managing liquid incinerable wastes, in particular highly chlorinated wastes.** Indeed, from several perspectives, the use of ocean incineration occupies a "middle ground." In a temporal sense, it is one of several options that could help bridge the gap between the practices of the past, which are being abandoned, and the preferred practices of the future (waste reduction, recovery, and recycling), whose capacity is only now developing. Several technical and economic factors would confine its applicability to a relatively small portion (less than 10 percent) of all hazardous wastes, although they are among the most toxic and concentrated of such wastes. Finally, with respect to both risks and benefits, ocean incineration falls midway between past and developing practices. For these reasons, ocean incineration could be a useful option today but is clearly not a panacea. Multiple waste management options must be developed if the Nation's hazardous waste problems are to be solved.

One of the major public concerns voiced over ocean incineration is that a need for the technology has not been demonstrated. Although it could play a role in meeting the expected near-term demand for alternatives to land disposal, OTA finds that an **absolute need** for ocean incineration cannot be analytically demonstrated for a number of reasons. The Nation could continue to rely on methods that are generally less tractable for such wastes. Moreover, predicting the rate at which preferred waste management practices will supplant the need for destruction methods such as ocean incineration is exceedingly difficult. (A legal requirement to demonstrate a need for ocean dumping—including ocean incineration—is contained in domestic and inter-

[3]The undestroyed fraction of the waste is released into the environment. Concerns about incineration generally focus to a greater degree on the magnitude and impact of these releases than on the magnitude and benefit of the destruction achieved.

## What Is Ocean Incineration?

The use of ocean incineration is both a relatively new and a relatively old phenomenon. Its use in Europe dates back to 1969 and has involved a total of six different vessels and hundreds of burns in the North Sea. Although the first U.S. research burn occurred in the Gulf of Mexico in 1974, ocean incineration has never been used on a routine commercial basis in the United States.

Incineration—whether on land or at sea—is intended to *destroy* wastes. The concept of *ocean* incineration combines the existing technologies of marine commerce in transporting hazardous chemicals and land-based incineration of hazardous wastes. The result is a tank ship capable of both transporting and burning hazardous wastes (see figure 1). The ship is designed to operate at a site far removed from human populations and vulnerable freshwater sources. Indeed, ocean incineration was originally developed to replace dumping of toxic chlorinated wastes directly into the ocean, a widespread practice at the time, and to solve several problems (both environmental and economic) associated with burning such wastes on land.[4]

### Ocean-Incinerable Wastes

Wastes suitable for ocean incineration are largely limited to liquid wastes with low metal content and with sufficient organic content to sustain combustion.[5] Such liquids comprise less than 10 percent of all hazardous wastes. A portion of these wastes is burned in land-based incinerators and, in some cases, in industrial boilers and furnaces.[6] Significant quantities of some of these wastes are currently recovered for reuse. Many of these wastes have relatively high energy content and are in demand for their fuel value; others must be supplemented with auxiliary fuel or high-energy waste to ensure full destruction.

Ocean-incinerable wastes fall into several major categories, including waste oils, chlorinated and nonchlorinated solvents, and other organic liquids. In addition, special wastes such as polychlorinated biphenyls (PCBs) have been or are proposed to be burned at sea. Most liquid incinerable wastes are generated in coastal States, near major ports. Almost all incinerable waste is subject to regulation under RCRA as hazardous waste.

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[4]The incineration of chlorinated (i.e., chlorine-containing) wastes generates a toxic and corrosive acidic gas, hydrogen chloride. On land, the gas must be neutralized through an expensive and difficult process, which itself generates a hazardous waste requiring disposal. At sea, the acid gas is neutralized by contact with seawater, which has a naturally high buffering capacity. Ocean incineration thereby avoids the problems encountered on land, but raises new environmental concerns.

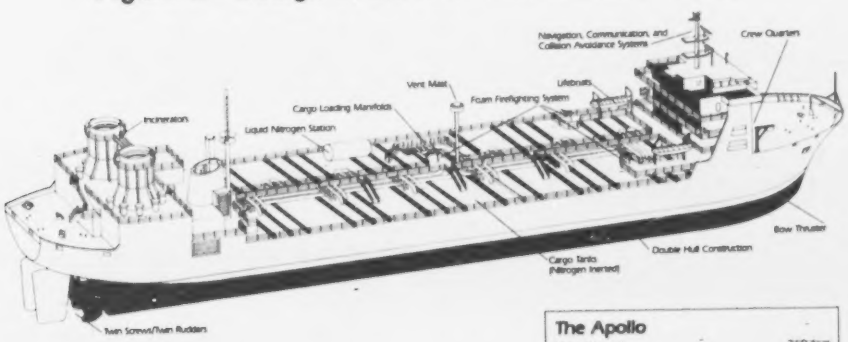
[5]Certain solid or sludge wastes that can be suspended in liquid waste to render them "pumpable" could also be incinerated at sea. Some land-based incinerators, including the type employed by most large commercial facilities, can burn a wide range of wastes, including organic solids and sludges, as well as liquids.

[6]Destroying hazardous wastes in boilers and furnaces is a common practice only beginning to be regulated; under current regulations (46 FR 7666, Jan. 23, 1981), this practice is distinguished from incineration because the wastes are burned in the boilers and furnaces for the *primary* purpose of recovering the energy content of the wastes, not for thermal destruction. EPA estimates that in 1981 almost twice as much hazardous waste was burned in boilers and furnaces as was burned in incinerators.

national regulations. No consensus exists, however, as to how this requirement should be interpreted and specifically applied to ocean incineration.)

OTA expects that ocean incineration would in general have only a limited effect on incentives for implementing preferred waste management practices. **Nevertheless, to ensure that the shift toward use of preferred practices is not impeded, any program for ocean incineration should be regarded**

**Figure 1.—Design of an Ocean Incineration Vessel**




| The Apollo | |
|---|---|
| Overall length | 369 feet |
| Beam | 60 feet |
| Gross tonnage | 4,850 tons |
| Liquid cargo capacity | 1.33 million gallons |
| Number of cargo tanks | 12 |
| Sustained sea speed | 10.7 knots |
| Range with full load | 6,940 nautical miles |

SOURCE: At-Sea Incineration, Inc.

**as interim**. It is important to ensure that, if permitted, reliance on ocean incineration can be lessened as we develop greater capacity in better waste management practices and reduce the generation of hazardous wastes. Within this context, ocean incineration could provide an attractive option for interim management of certain wastes.

## *The Role of Congress*

Despite its major involvement in shaping hazardous waste management policy, Congress has never directly addressed the issue of what role, if any, ocean incineration should play. As a result, the Federal Government's regulation of ocean incineration has evolved without any explicit indication of congressional intent. Although few hazardous waste management technologies have required direct congressional consideration, several special features of ocean incineration may necessitate that Congress examine public policy regarding this technology.

First, despite the fact that ocean incineration is used to destroy hazardous wastes, in many respects it falls outside of the policy and regulatory framework that Congress created, a framework that seeks to establish "cradle-to-grave" management of hazardous wastes. Because it takes place at sea rather than on land, ocean incineration has been placed into a different regulatory arena—under the umbrella of ocean dumping. The factors that originally motivated the regulation of ocean dumping, however, are somewhat at odds with the technology of ocean incineration, which involves wastes that cannot be directly dumped under present policy. Moreover, the intent of using this technology is to destroy wastes to the extent possible, in order to avoid the need for direct dumping (on land or at sea).[7]

[7]To a significant degree, this intent is accomplished; however, those wastes that are not destroyed are released directly into the marine environment.

Second, because of its nature and setting, ocean incineration entails a wide variety of activities that are regulated under numerous Federal statutes and agencies (see table 1). These include:

- land transportation of hazardous material by truck or rail;
- use and development of port facilities;
- federally regulated activity in States' coastal zones;
- marine transportation of hazardous material;
- transportation, storage, treatment, and disposal of hazardous waste;
- activities that can result in air or water pollution; and
- activities that can affect endangered species.

Third, the activities and possible consequences of ocean incineration typically cross political boundaries to encompass multiple State and municipal jurisdictions. The use of ocean incineration can take on international dimensions as well: waste or waste products released into the environment by ocean incineration may travel significant distances, and the site in the Gulf of Mexico designated by the United States is near the waters of other nations. Moreover, the potential for U.S. actions to set precedents for other nations must be considered.

Fourth, the level of controversy and significant public involvement in the debate over ocean incineration may warrant congressional attention. Although the initial public response often centered on local or regional concerns, the debate has become national in scope. As a result, ocean incineration is increasingly viewed in a broad context, as only one component in the process of shaping a national strategy for managing hazardous wastes.

These factors are not unique to ocean incineration, but their sheer number and systematic involvement in every application of this technology indicate a special need for an explicit policy toward ocean incineration, clearly defining what role, if any, the technology should play in managing hazardous wastes.

Congressional involvement in decisions regarding ocean incineration could take any of several forms. The fundamental decision of whether and, if so, how to proceed with ocean incineration requires consideration of numerous different technical and nontechnical factors. Many of these are regulatory in nature, but may require oversight or direction from Congress. However, other aspects of ocean incineration identified throughout this report raise questions regarding the adequacy and appropriateness of the current statutory authority

**Table 1.—Summary of Federal Regulatory Framework for Incineration**

| Statute/regulation | Agency | Activities: Ocean incineration | Activities: Land-based incineration |
|---|---|---|---|
| Resource Conservation and Recovery Act | U.S. Environmental Protection Agency (EPA) | Waste storage<br>Waste content<br>Land transportation<br>Residuals disposal | Waste storage<br>Waste content<br>Land transportation<br>Land incineration<br>Residuals disposal |
| Marine Protection, Research, and Sanctuaries Act | EPA<br>Coast Guard | Ocean incineration | — |
| Toxic Substances Control Act | EPA | Incineration of PCBs | Incineration of PCBs |
| Coastal Zone Management Act | States | Activities affecting land or water use in the coastal zone | Activities affecting land or water use in the coastal zone |
| Hazardous Materials Transportation Act | Department of Transportation | Hazardous waste transportation by truck or rail | Hazardous waste transportation by truck or rail |
| | Coast Guard | Transportation by water | — |
| Port and Tanker Safety Act | Coast Guard | Design, construction, certification, operation of incinerator vessels | — |
| Port and Waterways Safety Act | Coast Guard | Vessel movement through ports; waste storage, transfer at waterfront | — |
| Endangered Species Act | EPA | Compatibility of designated sites with protection of wildlife | — |
| Clean Water Act | EPA<br>Coast Guard | Cleanup of spills in territorial waters | Cleanup of spills in inland waters |
| Comprehensive Environmental Response, Compensation, and Liability Act (Superfund) | EPA<br>Coast Guard | National Contingency Plan, cleanup of spills | National Contingency Plan, cleanup of spills |

SOURCE: Office of Technology Assessment.

for regulating ocean incineration. The inclusion of ocean incineration under the rubric of ocean dumping and the lack of statutory authority to develop comprehensive regulations governing ocean incineration are two examples of such issues. If ocean incineration is permitted, resolution of these questions may necessitate clarifying legislative action on the part of Congress.

Finally, Congress could take specific action to decide the *fate* of the ocean incineration program. Such action would directly establish national policy toward use of this technology, and could help guide EPA and the public in determining whether and how ocean incineration should fit into the Nation's hazardous waste management strategy. In the absence of such action on the part of Congress, the ultimate fate of ocean incineration in the United States is an open question.

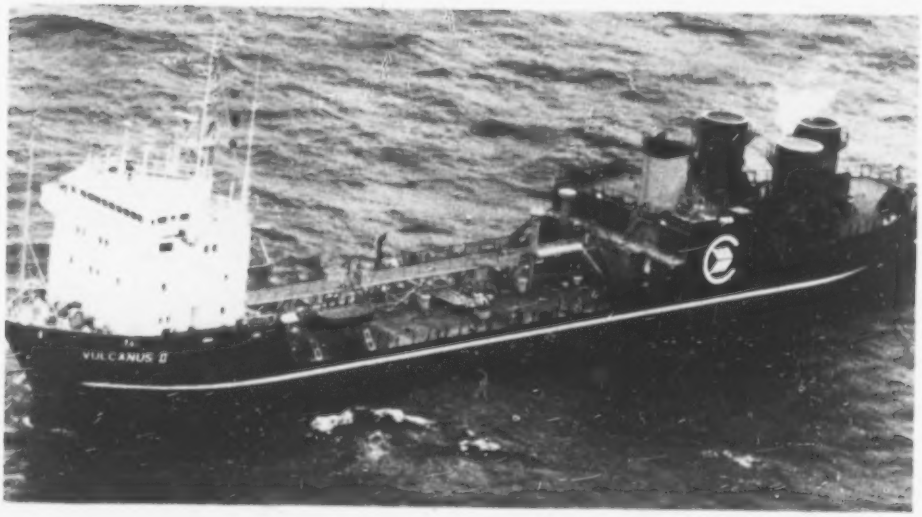



*Photo credit: Chemical Waste Management, Inc.*

The *Vulcanus II* incinerator ship.

## *Major Public Concerns*

Despite the routine use of ocean incineration for more than 15 years in Europe and more than a decade of trial experience in the United States, a regulatory program for ocean incineration has not yet been implemented.[8] Indeed, commercial ocean incineration, which has occurred only sporadically in this country, has been delayed at least temporarily, pending (at a minimum) final regulations and one or more research burns. A primary reason for the Nation's hesitance to embrace ocean incineration as a hazardous waste management technology has been the strong public opposition to it. The opposition reflects a broad spectrum of concerns, some specific to ocean incineration itself, and others symptomatic of the much larger problem of hazardous waste management in general.[9] These concerns include the following questions:

- whether EPA has fully considered both existing and developing alternatives to ocean incineration;
- whether ocean incineration is needed, in light of the available alternatives;
- whether the risks and consequences of spills on land or at sea resulting from transporting or handling of waste are sufficiently understood, and in particular, whether available means of responding to a spill are adequate;
- whether shipboard incinerators can adequately destroy wastes without posing unacceptable risks to the marine environment or to humans;

[8]EPA proposed regulations for ocean incineration in February 1985 (50 FR 8222, Feb. 28, 1985).

[9]A thorough and thoughtful discussion of the major areas of public concern is contained in the recent Hearing Officer's Report on the Tentative Determination to Issue the Incineration-At-Sea Research Permit HQ-85-001, issued by EPA on May 1, 1986, and in the Summary of Public Comments accompanying that report.

- whether the regulations, monitoring, and enforcement provisions proposed by EPA are sufficient to govern all phases of ocean incineration activities; and
- whether sufficient research has been conducted to justify the use of ocean incineration, given our level of understanding of the marine environment and the value of its resources.

In addition, the following areas of need have been identified in the public debate over ocean incineration:

- the need to develop an overall hazardous waste management strategy that would place greater emphasis on reducing wastes at their source and would clarify the role, if any, of ocean incineration in such a strategy;
- the need for adequate measures to ensure that users of ocean incineration are fully liable for environmental releases or damages resulting from ocean incineration, and, in particular, the need for measures to address the claims of injured parties in such cases; and
- the need to consider the integrity and past records of applicants for ocean incineration permits.

In addition to these and other specific issues, an overriding area of public concern is whether EPA can regulate ocean incineration in an effective and objective manner and be truly responsive to the public. The lack of public trust in EPA has its roots in the somewhat thorny history of U.S. involvement with ocean incineration, which is perhaps best illustrated by examining the **provisional** nature of the current regulatory program.

With regard to ocean incineration, the U.S. Government has undertaken three very different activities: research, regulation, and promotion. The relationships and boundaries between these activities have often been ill-defined, and EPA has not always fully appreciated the potential for conflicts of interest, or even the appearance of conflicts of interest. As a result, several such conflicts have arisen, three of which are discussed below:

1. EPA has never clearly communicated when and in what sequence it would conduct its ocean incineration research and develop its regulations. Consequently, questions have arisen as to whether the results of research burns carried out under the research strategy would be part of the data on which regulations would be based or whether EPA intended to develop and issue regulations before granting any permits (research or otherwise). Such unanswered questions have made the entire process appear haphazard.[10]
2. The government's promotional role culminated in the U.S. Maritime Administration granting a guaranteed loan to finance the construction of two incineration vessels by a private company.[11] Although the gov-

[10]EPA recently decided (51 FR 20344, June 4, 1986) to deny a proposed permit application for a research burn that the Agency had earlier solicited to serve as one component of its Ocean Incineration Research Strategy. In the decision, EPA stated that no permits, research or otherwise, will be granted until final regulations are promulgated. Although this statement clarifies current EPA policy, it raises questions about how the regulatory development process will be affected by the absence of information from the research burn that was intended to aid in that process.

[11]The company, Tacoma Boatbuilding, Inc., recently filed bankruptcy proceedings, and its subsidiary, At-Sea Incineration, Inc., was forced to default on its loan payments, due in large part to its inability to obtain an operating permit for the vessels.

ernment's promotion of ocean incineration may well have been based on a genuine belief that the technology was both needed and environmentally sound, many members of the public have questioned the wisdom of promoting the technology before developing a regulatory program. In the eyes of its critics, EPA has compromised its ability to fairly assess the merits and risks of ocean incineration.

3. EPA proposed to conduct its research burn in the North Atlantic Ocean at a site that has not been formally designated, and the Agency has yielded to other agencies the authority to regulate several important activities related to ocean incineration. Although clearly allowed or even required under existing regulations and statutes, such an approach makes the regulatory program seem tentative and fragmentary.

Many of the public concerns about ocean incineration can be addressed through technical or regulatory means, but the lack of credibility and public trust are, in many respects, far more difficult to overcome. If ocean incineration is to play a role in hazardous waste management, the government must not only address the specific issues listed above, but must also provide for meaningful public involvement in the decisionmaking process in a manner that restores public confidence.

### *Evaluating Ocean Incineration in a Broad Context*

As the previous discussion suggests, developing a policy for ocean incineration will require Congress to reexamine its policy towards the management of hazardous wastes as a whole. Legitimate concerns have been raised over the need for ocean incineration, the risks it poses to the environment, and the numerous unresolved questions and uncertainties regarding its use. These concerns are best viewed in the context of the corresponding availability, risks, and unknowns associated with alternative methods for managing incinerable waste. This is true for at least two reasons: no methods are free of risk and uncertainty, and a decision not to employ one method necessarily results in the use of other methods.

Thus, resolution of the debate over ocean incineration will require a thorough and objective *comparative* assessment of the technology. In particular, the full range of available choices and the trade-offs they entail must be clearly communicated.

In developing the analysis presented in this assessment, OTA encountered many issues whose dimensions extend well beyond the confines of ocean incineration, and often beyond those of hazardous waste management in general. Some of these issues include:

- the possibility that allowing the use of existing treatment and disposal methods would serve as a disincentive for developing and using better methods;
- the risks and regulation of hazardous materials transportation;
- problems with regulatory enforcement;
- the government's capacity to monitor for adverse environmental impacts;
- the complexity of the hazardous waste market and its response to changes in the regulatory or economic climate;

*Photo credit: Valley Morning Star, Harlingen, Texas*

Over 6,000 people attended an EPA public hearing held in Brownsville, Texas, in 1983. The hearing, which concerned whether a permit should be granted for incineration of PCB- and DDT-containing wastes in the Gulf of Mexico, was the largest public hearing in EPA history and reflected intense public concern about the technology.

- the adequacy of liability provisions applicable to hazardous waste management;
- the difficulties associated with the siting of hazardous waste management facilities; and
- the need to develop appropriate means of involving the public in the decisionmaking process.

## MAJOR FINDINGS

### *The Potential Role of Land-Based and Ocean Incineration*

**As much as 10 to 20 percent of the estimated 250 million metric tons of hazardous wastes generated in the United States each year *could in theory be* incinerated. Nearly half of all incinerable wastes (up to about 8 percent of all hazardous wastes) are liquids that could be incinerated at sea. Currently, however, only about 1 percent of hazardous waste is actually incinerated, and all of the incineration occurs in land-based facilities.**

**A broad range of practices is used for managing incinerable hazardous wastes today. Significant quantities of such wastes (as much as one-third) are recovered or recycled. Even larger quantities (as much as 65 percent), however, are being disposed of on land (in underground injection wells, landfills, or surface impoundments) or burned as fuel in boilers and furnaces.**

Although a number of innovative treatment technologies now under development will ultimately be preferable to incineration, **today's land-based and ocean incineration technologies represent a significant improvement over land disposal of incinerable wastes.** A properly operating incinerator can permanently destroy 99.99 percent or more of such wastes, in marked contrast to land disposal, in which wastes remain hazardous for long periods of time.

Numerous studies have examined future demand for incineration capacity *in general.* Surveys conducted by both private and governmental organizations (including EPA, the Congressional Budget Office, numerous State and regional hazardous waste management planning commissions, and several waste generating industries) predict that **this demand will continue to grow into the foreseeable future.** Projections indicate that increased quantities of hazardous waste will be generated and will be managed through incineration. For example, current regulations mandate that waste containing high concentrations of polychlorinated biphenyls be incinerated. In addition, if implemented even roughly on schedule, the 1984 RCRA Amendments will restrict the land-based alternatives traditionally used for disposing of incinerable wastes and are expected to substantially increase the amount of waste available for incineration.

**Despite this expected demand, existing incineration capacity is significantly below what would be needed to burn all incinerable wastes. Moreover, this shortfall is likely to increase with time,** largely as a result of two factors: first, the increase in demand described above; and second, the very slow development of new capacity. Indeed, efforts to increase incinera-

tion capacity have encountered many obstacles, including public opposition, limited availability of liability insurance, and difficulties in facility siting.

Despite this shortfall, a future *need* for ocean incineration (or land-based incineration, or any other hazardous waste management technology) may never be demonstrated or quantified from an *analytic* standpoint. The regulatory status, economic attractiveness, capacity, and actual use of each technology for managing incinerable waste vary widely, change with time, and are exceedingly difficult to predict. It is the complex interaction of these factors that determines the market or need for any individual option. **Thus, although establishing or estimating a specific need for ocean incineration is virtually impossible, a need clearly exists for having available a number of technologies capable of managing incinerable wastes.**

**For highly chlorinated wastes, ocean incineration may be preferable to available alternatives, with respect to human health risks and cost-effectiveness (see section below on technological limitations).**

**For other wastes, certain existing technologies may offer economic or environmental advantages over both land disposal and incineration.** Current competing alternatives such as industrial boilers and furnaces burn wastes with high heat content to recover energy; these practices, however, are currently subject to significantly less regulatory control than is incineration and may, in some cases, pose significant environmental or human health risks. Other alternatives allow the recovery of materials from the waste. Solvent distillation, oil reclamation, chlorination processes, and hydrogen chloride recovery are examples of this approach. The use of such technologies for managing hazardous wastes, including developing a proper regulatory framework, should be explored further.

**Certain emerging waste reduction and treatment options will ultimately prove to be an even greater improvement over the incineration technologies now available, although accurately estimating their near-term availability and capacity is not currently possible.** In any case, the need for waste treatment and disposal options will continue because of the sheer quantities of wastes, the time required to implement waste reduction measures and to develop sufficient capacity for recycling and advanced treatment, and the fact that not all wastes will lend themselves to such techniques.

### *Comparison of Land-Based and Ocean Incineration*

**If additional capacity to incinerate liquid wastes is developed, the choice between expanding land-based incineration or developing ocean incineration cannot currently be resolved on a technical basis.** Nor will the collection of more information be likely to significantly aid in answering this question. When specific technical factors are analyzed one at a time, one technology may seem clearly preferable to the other, but when all such factors are considered as a whole, the analysis does not lead to an unambiguous choice. Several areas of comparison between land and ocean incineration are particularly important to consider.

### Regulation

**In general, the proposed regulatory framework for ocean incineration is more stringent and explicit than the existing regulations that govern land-based incineration.** Technical limitations and performance standards, as well as requirements for obtaining permits, monitoring, and reporting, tend to be more involved and leave less to the judgment of those issuing permits for ocean incineration.

In part, the regulatory differences reflect the fact that the two technologies are addressed under different primary statutes. However, they also appear to reflect two other factors: heightened public concern over ocean incineration, and greater perceived and actual difficulties in monitoring an activity that takes place far from shore.

### Releases of Waste

**Releases of waste from the actual incineration process should be equivalent for land-based and ocean incineration, although the nature and location of these releases could differ substantially. Because ocean incineration requires additional transportation and handling of hazardous wastes, however, it is likely to result in a somewhat greater release of waste to the environment than would land-based incineration.**

EPA proposes that incineration vessels not be required to have air pollution control equipment, which is required on some, but not all, land-based

**Table 2.—Accidental Releases From Land-Based and Ocean Incineration**

| Activity | Cause of release | Type of release | Relevant mode |
|---|---|---|---|
| Waste pickup/loading/unloading: | | | |
| Drums | Mishandling | Spill on land | Land/ocean, bulk |
| Bulk liquids | Overfilling, line break | Spill on land | Land/ocean, bulk |
| Containers | Mishandling | Spill on land | Land/ocean, containerized |
| Road or rail transit | Vehicle accident, tank or valve leak | Spill on land<br>Fire | Land/ocean, bulk/containerized |
| Storage: | | | |
| At dockside | Tank or container failure | Spill on land | Ocean |
| At incinerator | Tank or container failure | Spill on land | Land |
| Vessel loading | Overfilling, line break | Spill on land, water, or ship | Ocean, bulk |
| Vessel transit | Collision or grounding | Spill to water or on ship | Ocean, bulk |
| Incineration | Upset or malfunction | Increased emissions | Land/ocean, bulk/containerized |
| Bulk liquids or containers | Mishandling | Spill | |

SOURCE: Arthur D. Little, Inc., *Overview of Ocean Incineration*, prepared by J.R. Ehrenfeld, D. Shooter, F. Ianazzi, and A. Glazer, contract report prepared for the U.S. Congress, Office of Technology Assessment (Washington, DC: May 1986).

incinerators.[12] This factor would not alter the *total* quantity of waste products released during the actual incineration process. The quantity of such products *directly released through the stack* would be greater for ocean incinerators than for land-based incinerators equipped with scrubbers. However, operating a scrubber generates a hazardous waste containing pollutants that would otherwise have been emitted; this waste must be disposed of and may itself be released to the environment, with potential to contaminate groundwater or surface water.

The *size* of a release is only one factor that influences the severity of impact. The nature and location of expected releases must also be considered. Land-based and ocean incineration differ significantly with respect to these factors.

### The Issue of Scrubbers

The major technological and regulatory difference between land-based and ocean incineration is the absence of scrubbers on ocean incineration vessels. Scrubbers are present on approximately 45 percent of existing land-based incinerators, including all of the large commercial facilities that would offer the most direct competition to ocean incineration.

The debate over the need for scrubbers on incineration vessels has been clouded by two common misperceptions regarding scrubber and incinerator performance. The first involves the issue of which particular waste products are actually removed by scrubbers. Scrubbers are generally very effective at removing acid gases (e.g., hydrogen chloride) and particulate emissions (which include a large portion of toxic metals), but are *not* effective at removing residual organic material—unburned wastes or products of incomplete combustion.

A second misperception is that a difference exists between the emissions of organic material that are allowed for land-based and ocean incineration. The performance of ocean incinerators (as well as land-based incinerators lacking scrubbers) is to be measured by calculating a destruction efficiency (DE). The performance of land-based incinerators that carry scrubbers is measured by calculating a destruction *and removal* efficiency (DRE), after emissions have passed through the scrubber. The DE standard proposed for ocean incineration is identical to the DRE standard for land-based incinerators with scrubbers. Hence, emissions from ocean incinerators could not be any greater than those from land-based incinerators, even *after* accounting for any incidental removal of organic material accomplished by the scrubber. In other words, even if scrubbers were effective at removing organic material from stack gases, ocean incinerators would still be held to the *same* overall destruction performance standard.[13]

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[12]Such equipment is generally referred to as "scrubbers." Land-based incinerators burning chlorinated liquid wastes or solid wastes generally possess scrubbers, as do the large land-based *commercial* incinerators. Other land-based incinerators that burn other types of liquid wastes often do not; use of these facilities generates emissions equivalent to incinerators at sea burning the same waste.

[13]Several shortcomings in the operational definitions of DE and DRE have been identified. Because the shortcomings apply equally to land-based and ocean incineration, however, they do not aid in the comparative evaluation.

For these reasons, an evaluation of the need for scrubbers at sea should focus on hydrogen chloride and particulate emissions. For these pollutants, EPA's rationale for not requiring scrubbers on incineration vessels is that:

- hydrogen chloride gas emissions would be rapidly neutralized because of the high natural buffering capacity of the marine atmosphere and seawater, and
- particulate emissions would be minimal because of the specific limits placed on metal content of wastes to be incinerated at sea and the fact that incineration of liquid wastes generates fewer particulates than does incineration of solid or mixed wastes.

**Hydrogen Chloride Gas Emissions.**—A review of available data reveals little documentation for any significant adverse environmental impacts attributable to hydrogen chloride gas released from incineration vessels. Before 1979, incineration in the North Sea took place at a site only 23 miles off the Dutch coast. Although no causal link to ocean incineration was established, the presence of a slightly irritating acidic atmosphere along the coastline was reported and was one factor leading to the movement of the incineration site to a new area more than 60 miles from the nearest shore. Designated or proposed U.S. sites are 140 to 190 miles from the nearest shoreline.

Acid wastes of a much higher concentration than would be emitted through ocean incineration are directly dumped at two industrial waste disposal sites in the North Atlantic Ocean. Although this direct dumping has caused some short-term and localized perturbations in the alkalinity of the seawater, complete neutralization occurs within a few hours after the dumping and no adverse effects on marine life have been detected. In ocean incineration, the much lower concentrations of acid would be deposited over a larger area and over a longer period of time than is the case in direct dumping. Indeed, past monitoring of ocean trial burns did not detect any change in the alkalinity of surface waters that came into direct contact with the incinerator plume. The potential for damage to occur to organisms in the surface microlayer prior to dispersion or neutralization, however, has not been adequately addressed.

EPA has proposed an environmental performance standard that would allow only a very small change in the alkalinity of seawater at an incineration site. EPA's calculations indicate that this standard would easily be met even under extreme circumstances.

According to the chairman of the committee that prepared the Science Advisory Board report on ocean incineration, these and other considerations led the SAB to conclude that using the buffering capacity of the ocean to neutralize acidic emissions from ocean incinerators did not pose any major problems.

**Particulate Emissions.**—Incinerating hazardous waste generates particulate matter that is composed primarily of metals, along with other inorganic material originally present in the waste. The chief motivation for controlling particulate emissions is that, in the process, a significant portion of toxic metals is also controlled.

Two different approaches to controlling metal emissions have been applied to land-based and ocean incineration. On land, stack scrubbers are utilized to trap particulates, but relatively little control is exercised over the metal content of wastes to be incinerated. At sea, rather than require scrubbers, EPA has proposed to limit the metal content of wastes accepted for incineration. Emissions of some metals would be further limited by an environmental performance standard that would prohibit applicable marine water quality criteria to be exceeded.

In addition to the amount of a metal present, its *chemical form* affects its behavior in the environment, its potential to cause adverse impact, and in some cases the efficiency with which it is removed by a scrubber. The insufficient characterization of incinerator emissions described previously extends to determining the chemical form, as well as quantity, of particular metals. **It is essential that such a characterization be undertaken if the absence of a requirement for scrubbers on incineration vessels is to be justified.** Further regulation of metal emissions may well be warranted, given EPA's finding that most of the human health risks associated with ocean incineration are derived from metal emissions.

As a final consideration, available data indicate that even under the most extreme circumstances allowed under EPA's proposed regulation, the total amount of metals released into the marine environment from ocean incineration would be very small in comparison to the amount from other sources and permitted activities.

Although determining the appropriate limits for metals in wastes to be incinerated at sea certainly requires further scrutiny, **based on the available information, OTA finds that the lack of a requirement for air pollution control equipment on ocean incineration vessels appears justified, so long as operating conditions and the metal content of wastes incinerated at sea are appropriately regulated and such activity is linked to a rigorous environmental monitoring program.**

### Health and Environmental Risks

Land-based and ocean incineration each involve several kinds of risks, some of which are unique to one technology, others common to both. Their *primary* risks differ substantially, however, thus constraining any quantitative comparison of these technologies. Consideration of these primary risks is, nevertheless, essential in determining policy toward the use of incineration.

**Because land-based incineration occurs relatively close to human populations, its primary risk is the potential for adverse impact on human health—resulting from exposure to routine or normal releases of waste or waste products.** A full understanding of the magnitude of this risk is constrained by our lack of knowledge concerning the nature of incinerator emissions and the difficulties associated with environmental monitoring of land-based incinerators.

**In contrast, ocean incineration's primary risk is to the marine environment. Most of this risk derives from the potential for a major accidental**

**spill.** By all estimates, such an event would be extremely unlikely to occur, even less likely than a spill resulting from the transportation of nonwaste hazardous materials. However, a major spill of either hazardous waste or nonwaste material could have catastrophic consequences; for example, if it occurred in a sensitive estuarine area, large-scale loss of fish and bottom-dwelling organisms could result. The situation would be exacerbated by the acknowledged difficulty or impossibility of cleanup.

**The major risk to human health from ocean incineration is expected to arise from exposures due to the transport and handling of wastes on land.** In this respect, land-based and ocean incineration appear to be quite similar.

### Unanswered Questions

EPA's Science Advisory Board has identified many unanswered questions, regarding performance and emissions, that apply to both land and ocean modes of incineration and, in some cases, to all combustion processes.[14] For example, the SAB stated that no reliable characterization of emissions or their toxicities is available for either technology, which means that the potential for exposure and adverse impact to the environment or to humans cannot be adequately assessed. The study also challenged EPA's method of evaluating the total performance of both land-based and ocean incinerators by measuring destruction efficiency for only a few selected compounds. The SAB recommended that EPA undertake a complete characterization of emissions and products of incomplete combustion arising from both technologies.

### Technological Limitations

Because land-based and ocean incineration each possess inherent capabilities and limitations, from a technical perspective **certain wastes are better managed by one or the other technology.** Two examples of such factors are discussed below.

First, **because they cannot incinerate solids and sludges, ocean incinerators are inherently less versatile than land-based rotary kiln incinerators, despite their greater capacity.** Such a limitation can be especially important in local or regional settings, where a variety of waste types may need to be incinerated. In addition, applying waste recovery and recycling technologies to incinerable wastes is expected to increase the amounts of incinerable solids and sludges at the expense of incinerable liquids. For these and other reasons, a number of States plan to build land-based rotary kiln facilities to meet their anticipated needs. It is not known how much and how soon such efforts might affect the shortfall between capacity and demand for incineration.

Second, despite the limitation discussed above, incineration of highly chlorinated wastes at sea has commonly been preferred over their incineration on land. Indeed, in both Europe and the United States, ocean incineration

[14]Such processes include the burning of fossil fuels in powerplants, the burning of gasoline in automobiles, and even the burning of wood in fireplaces.

has been employed almost exclusively for highly chlorinated wastes. The extensive rationale for this is based on the fact that incinerating such wastes generates high concentrations of corrosive and toxic hydrogen chloride gas. For numerous reasons related to this finding, **incineration of highly chlorinated wastes at sea may be advantageous**:

- Incineration of such wastes on land requires the use of scrubbers, which are costly and difficult to operate and maintain.
- Scrubber operation generates additional hazardous waste that must be disposed of, typically through neutralization and discharge into sewers or surface impoundments. These practices can in turn contaminate groundwater or surface water.
- Limitations on the chlorine content of waste are often written into the operating permits of land-based incinerators, for three reasons:
  —Certain highly chlorinated wastes can, in fact, exceed the feasible capacity of scrubbers for removing hydrogen chloride gas.
  —The energy content of a waste decreases as the chlorine content increases. Thus, for a given feed rate, as chlorine content increases a point is reached where insufficient energy is present to ensure combustion.
  —Free chlorine gas, which is even more toxic to humans than hydrogen chloride gas and is *not* efficiently removed by scrubbers, is generated during the incineration of highly chlorinated wastes. As a result, an upper limit on the chlorine content of wastes must be set, usually at about 30 percent.

  In light of these factors, highly chlorinated wastes can be burned on land only if they are blended with auxiliary fuel or nonchlorinated wastes to reduce the chlorine content and increase the energy content of the waste being incinerated. The net effect is a reduction in the effective capacity of land-based incinerators for *chlorinated* wastes.
- Ocean incineration vessels are not required to have scrubbers, because of the capacity of seawater to neutralize hydrogen chloride gas, and because the incinerators operate at a location far removed from human populations.
- Because they lack scrubbers, ocean incinerators can burn chlorinated wastes at a much higher rate than can land-based incinerators. Consequently, ocean incineration has a greater capacity for chlorinated wastes. Moreover, the higher feed rate reduces or obviates the need to use supplementary fuel or high energy wastes.

**Thus, from the perspectives of human health risks, capacity, and cost-effectiveness, incinerating highly chlorinated wastes at sea may be preferable to incinerating them on land.** These benefits must be balanced against the potential risks ocean incineration poses to the marine environment.

### *Releases of Waste to the Marine Environment*

Releases of waste and risks of impact from ocean incineration should properly be viewed in the context of releases and risks from comparable activities and from other sources of marine pollution. Only in such a context can the significance of such risks in relation to potential benefits be fully assessed.

**Ocean incineration entails a very small incremental increase in risk relative to that routinely borne by this Nation in the marine transport of hazardous (nonwaste) materials** (see table 3). This is the case with respect to the number of transits, quantities and types[15] of material carried, and the expected frequency and size of releases. **However, given the potentially catastrophic consequences of a major marine spill, the acknowledged difficulty or impossibility of cleanup, and the intense public concern focused on this issue, extensive regulatory attention would be warranted if ocean incineration were permitted.** This should include consideration of measures beyond the already substantial provisions that exist or have been proposed by EPA and the U.S. Coast Guard.

In certain settings, the normal operation of incineration vessels may represent a small but potentially significant contributor of some pollutants to the marine environment. **This contribution, however, is expected to be considerably smaller than that of other permitted activities that introduce pollutants to marine waters.** Furthermore, pollutants released during

[15]One major exception is special wastes, such as PCBs, which are no longer commercially produced and are therefore not routinely transported, except as waste.

**Table 3.—Annual Tonnages of Hazardous Materials and Crude Petroleum Passing Through Various U.S. Ports in 1984**

| Location | Quantity Transported in 1984 (millions of metric tons) | | | Quantity normalized to one *Vulcanus* vessel |
|---|---|---|---|---|
| | Hazardous materials[a] | Crude petroleum | Total | |
| Total for all U.S. ports (1983)[b] .... | — | — | 1,384 | 21,290 |
| Port of New York ..... | 104 | 8 | 112 | 1,723 |
| Delaware River/Bay ..... | 26 | 46 | 72 | 1,108 |
| Port of Mobile, AL ..... | 3 | 3 | 6 | 92 |
| Port of Lake Charles, LA..... | 20 | 7 | 27 | 415 |
| Houston Ship Channel, TX ..... | 46 | 11 | 57 | 877 |
| San Francisco Bay, CA ..... | 25 | 26 | 51 | 785 |
| | | | Annual quantity[c] | |
| One incineration vessel | | | | |
| *Vulcanus* ..... | | | 0.065 | 1 |
| *Apollo* ..... | | | 0.100 | 1.5 |
| 30 incineration vessels | | | | |
| *Vulcanus* ..... | | | 2.0 | 30 |
| *Apollo* ..... | | | 3.0 | 46 |

[a]Includes the following commodities:

| | | |
|---|---|---|
| Sodium hydroxide | Basic chemicals | Jet fuel |
| Crude tar, oils, gas | Paints | Kerosene |
| Dyes, pigments | Gum, wood chemicals | Distillate fuel oil |
| Alcohols | Insecticides, disinfectants | Residual fuel oil |
| Benzene and toluene | Miscellaneous chemicals | Lubricating oil and grease |
| Sulfuric acid | Gasoline | Naptha, petroleum solvents |

[b]This 1983 quantity is cited in the preamble to EPA's proposed Ocean Incineration Regulation, 50 FR 8226, Feb. 28, 1985. The data are originally derived from the Waterborne Commerce Statistics of the U.S. Army Corps of Engineers. A national total for 1984 was not available at the time of publication of this report.
[c]Estimates based on information obtained from vessel owners.

SOURCE: Office of Technology Assessment, based on U.S. Army Corps of Engineers, *Waterborne Commerce of the United States*, Freight Traffic Tables for Calendar Year 1984.

normal incineration operations would result in virtually no detectable long-term increase over background levels, except in extreme circumstances.

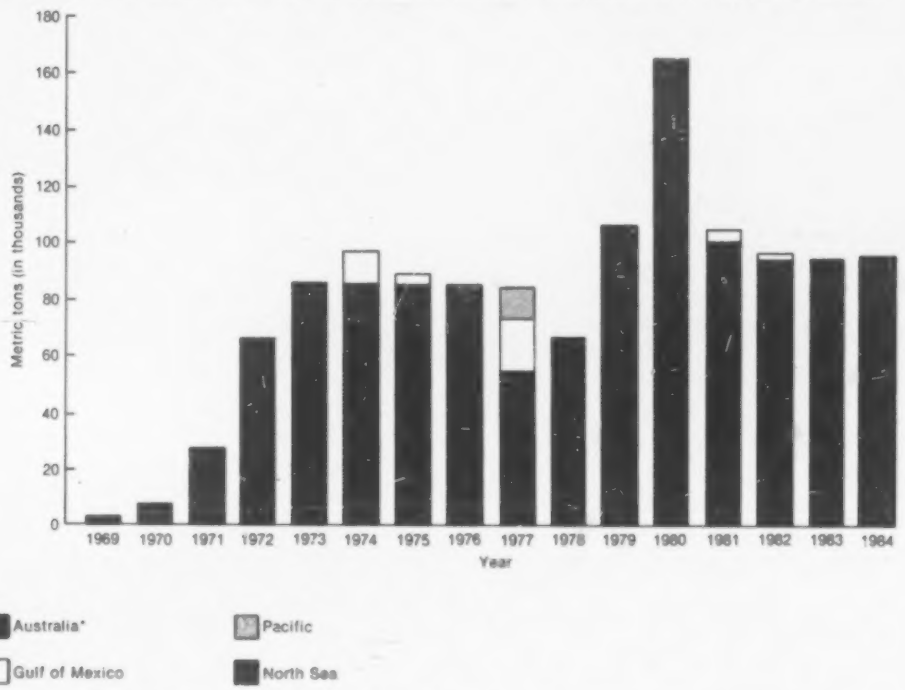
Prior to dispersing, pollutants emitted by ocean incinerators could cause short-term adverse impacts upon contact between the incinerator plume and the ocean surface. Although the affected region is expected to be limited to a small area along the path of the ship, in this region significant damage could result. Further study of such impacts, particularly on the surface microlayer, is warranted.

### *Past and Current Use of Hazardous Waste Incineration*

Ocean incineration has been employed in the United States only on a research or interim basis, but has been used routinely in the North Sea for European wastes for more than a decade (see figure 2). Two incinerator ships are currently operating in Europe;[16] two have recently been built in the United States, but have yet to be employed commercially. Several other companies have expressed interest in the market.

[16]The two vessels are the *Vulcanus II* and the *Vesta*; the *Vulcanus I* is operational but not currently active.

**Figure 2.—Quantities of Waste Annually Incinerated At Sea, 1969-84**




*This waste was generated in Australia and incinerated while the ship was en route to Singapore.

SOURCE: Ocean Combustion Service, "15 Years of Waste Incineration At Sea: History, State of the Art, Control, Environmental Impact" (Rotterdam, The Netherlands: Ocean Combustion Service, February 1985); M.K. Nauke, "Development of International Controls for Incineration At Sea," in *Wastes in the Ocean*, vol. 5, D.R. Kester, et al. (eds.) (New York: John Wiley & Sons, 1985), pp. 33-52; and International Maritime Organization, "Consideration of Report on Dumping, Draft Report of Permits Issued in 1982," document LDC/SG.8/INF.3, prepared for 8th Meeting of Scientific Group on Dumping (London: Dec. 20, 1984).

The technological performance and environmental effects of ocean incineration have been subjected to considerable testing. Unfortunately, the results of this effort are hotly contested, and do not aid substantially in evaluating the safety of ocean incineration. The test data appear to support two somewhat conflicting findings:

1. Ocean incineration can, at least under certain conditions, meet applicable regulatory and technical requirements and achieve very efficient destruction of hazardous wastes.
2. The technology's ability to perform in such a manner consistently has not been demonstrated for complex mixtures of wastes or the broad range of operating and environmental conditions likely to be encountered.

### *Recovery, Recycling, and Reduction of Incinerable Wastes*[17]

Recovery, recycling, and reduction practices are generally given preferred status in the hazardous waste management hierarchy discussed previously. Many critics of ocean incineration argue that allowing its development would impede efforts to implement these preferred practices. (In the following discussion, a distinction is drawn between waste *recycling/recovery* and waste *reduction*.)

Some wastestreams comprising incinerable waste are very amenable to recovery and recycling processes. Much of this potential, however, is already being realized. For example, large quantities of waste solvents (as much as 70 percent) and oils (about 10 percent) are currently recovered. Several advanced thermal destruction techniques can recover or reutilize the chlorine content of chlorinated wastes. These technologies, however, have only been used on a small scale, primarily in Europe, and are not competitive with other sources of the recovered material. They have not been employed commercially in the United States and provide little or no capacity at the present time. Thus, **only modest increases in *recovery and recycling* of liquid organic hazardous wastes are expected in the near future.**

**Much of the anticipated increase in recovery and recycling of hazardous wastes in the near future will involve wastestreams that have little or no potential for incineration, for example, metal-containing liquids and sludges.** Development of ocean incineration and expansion of land-based incineration would not be expected to affect incentives for recycling or recovery of these nonincinerable categories of waste.

**Estimating to what extent the implementation of waste *reduction* practices will affect the quantity of incinerable wastes generated is virtually impossible. In large part, this uncertainty is due to the lack of data and even appropriate means to measure waste reduction.** The visibility and application of waste reduction measures are clearly increasing, and their potential to reduce the generation of hazardous waste is enormous. It is equally clear, however, that major institutional, economic, and attitudinal obstacles impede its widespread application in the near future.

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[17]These issues are explored in another OTA report, "Serious Hazardous Waste Reduction for Pollution Prevention and Industrial Efficiency," in press.

Even the most optimistic observers of ocean incineration project a total industry of only several ships, which together would be capable of incinerating a small fraction of incinerable liquid waste, and an even smaller fraction of all hazardous waste. This probable market picture—together with limited or uncertain application of reduction, recovery, and recycling practices to incinerable wastes—argues that **the development of ocean incineration, as an interim option, would be expected to have a very limited effect on overall incentives for using these practices**. There is no consensus, however, regarding this conclusion. Indeed, some critics strongly contend that ocean incineration will have a significant adverse effect on such incentives. OTA's policy options (discussed below) include provisions that could be used to ensure that the shift toward use of preferred practices is not impeded.

Recovery processes applied to liquid wastes generally produce residuals. Thus, increasing use of such processes is likely to increase the quantities of incinerable sludges and solids (which cannot be incinerated at sea) relative to the quantities of ocean-incinerable liquids. Many residuals from product purification as well as recovery processes, however, are in liquid form and are prime candidates for ocean incineration.

**Thus, although significant long-term potential remains for further application of recovery and other emerging technologies, in the near-term they appear unlikely to substantially reduce the amount of incinerable waste (liquids as well as sludges and solids) requiring management through currently available means.**

### *The Use of Ocean Incineration by Other Nations*

Ocean incineration of hazardous wastes has been used routinely in Europe since 1969, and two incineration vessels are currently operating full-time in the North Sea. Opinions and positions regarding the future use of ocean incineration vary greatly among European and other developed nations. General agreement exists that incineration at sea should be viewed as an *interim* method for managing wastes, to be used only when preferable land-based alternatives are unavailable. No consensus currently exists, however, regarding when it will be possible to terminate its use.

In 1985, a survey of Member States of the Oslo Commission, which includes most Western European nations, documented the following trends:

- The major constraint blocking termination of ocean incineration is the lack of land-based capacity for chlorinated hydrocarbon wastes.
- It is expected that by 1990 wastes will remain for incineration at sea.

Certain nations, such as Denmark and Sweden, argue for termination as soon as possible; some nations, such as The Netherlands and the Federal Republic of Germany, regard ocean incineration as a necessary method for the foreseeable future because land-based incineration capacity is lacking; and other nations, such as the United Kingdom, view ocean incineration of certain wastes to be the best practicable environmental option.[18]

[18]There are further indications of the ambiguity with which Europeans view ocean incineration. For example, both The Netherlands and the Federal Republic of Germany have reported that they anticipate significant decreases in their reliance on ocean incineration as a result of increases in land-based capacity. More

*(continued on next page)*

### *Conclusion*

The preceding discussions suggest the possibility that ocean incineration, carried out under a sufficiently rigorous and comprehensive regulatory framework, could be one of several options to fill an interim need in hazardous waste management. Under such a scenario, ocean incinerators would focus on highly chlorinated liquid wastes (possibly including special wastes such as PCBs) that can be advantageously burned at sea because of the absence of a requirement for scrubbers. Land-based incinerators might concentrate on wastes that could not be burned elsewhere—organic sludges and solids with relatively high metal content and relatively low energy value. Liquids with high heat content but little or no chlorine might continue to be burned in industrial boilers and furnaces, though under stricter regulation where appropriate. Much of the expected application of waste recovery and recycling to incinerable wastes is expected to be applied to such liquids, and thus will produce organic sludges appropriate for land-based incineration. As capacity develops in better technologies, and as waste reduction practices are increasingly implemented, the use of ocean incineration should be concomitantly decreased.

## DECIDING THE FATE OF OCEAN INCINERATION: MAJOR POLICY OPTIONS

Out of the controversy and polarization surrounding the development of ocean incineration, several disparate perspectives have emerged regarding whether and, if so, how to use this technology. The fundamental choice of *whether* to proceed cannot be resolved on a technical basis; it will require difficult political choices as well. Much of the debate has focused on the *whether* question in an all-or-none fashion. Certain intermediate alternatives, however, might be considered that would allow some use or further investigation, carried out in a manner that directly addresses the areas of disagreement.

Because ocean incineration has the potential to play an important but limited interim role in managing hazardous wastes, there is a need to consider a broad range of possible approaches to its use, including certain intermediate options. This intent is reflected in four distinct policy options OTA has identified:[19]

- *Option 1*: Halt the development of ocean incineration permanently and rely entirely on land-based options.
- *Option 2*: Halt commercial ocean incineration temporarily, until more research is completed. The research would probably require a few burns at sea to collect data needed to evaluate incinerator performance, to characterize emissions, and to assess environmental impacts.

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recently, however, The Netherlands announced plans to conduct a trial burn of PCBs, in anticipation of the need for the ocean incineration option resulting from the loss of the country's land-based incineration capacity for PCBs.

[19]This discussion is limited to consideration of policy options that affect the *fate* of ocean incineration. If a decision were reached to proceed with ocean incineration, numerous additional issues and options related to the *shaping* of an actual program would need to be addressed. Resolution of some of these issues may require regulatory action on the part of EPA or oversight on the part of Congress; others may necessitate additional legislative action.

- *Option 3*: Proceed with a commercial ocean incineration program under the regulatory framework being developed by the Environmental Protection Agency.[20]
- *Option 4*: Proceed with a *modified* ocean incineration program that would accomplish one or more of the following:
  A. include provisions that impart an *interim* status to the program;
  B. strengthen regulatory requirements where necessary to address areas of deficiency or continuing public concern; and/or
  C. provide for greater direct involvement by the government in the actual operation of ocean incineration.

For options 3 and 4, numerous factors would determine the scale of the program. These include influences from market factors, government intervention, public opposition, and modification of the regulatory program in response to new information. Many of the factors could be subject to direction through regulatory or economic measures, but others would be more difficult to predict or control.

## *Policy Options and Their Implications*

Each of these policy options has certain implications when viewed in the context of overall management of hazardous wastes. Moreover, each choice necessarily engenders additional decisions that must be made. Some of the possible implications of each option are presented below.

**Option 1:**
**Halt the development of ocean incineration permanently and rely entirely on land-based options.**

**Implications**

1. Land-based incineration capacity for incinerable wastes would lag even further behind demand. If three of the existing incineration vessels were used, the *commercial* incineration capacity for liquid wastes would roughly double. In their absence, efforts to expand the capacity of land-based incineration or other alternative technologies would need to increase.

2. The increased shortfall between incineration capacity and demand might cause some limited increase in incentives for waste reduction, recycling, and innovative treatment of incinerable liquids. The need for currently available waste treatment options would clearly continue into the foreseeable future, however, because of the sheer quantities of wastes, the time required to implement waste reduction measures and to develop sufficient recycling capacity, and the fact that not all wastes will lend themselves to such techniques.

3. If sufficient alternative capacity were not developed, wastes would continue to be disposed of on land, often using practices that pose demonstrated risks to the environment and human health. Under the Hazardous and Solid

[20]EPA's developing regulatory framework is represented, for the most part, by EPA's proposed Ocean Incineration Regulation (50 FR 8222, Feb. 28, 1985). Several substantial changes are expected during finalization of this regulation, some of which may directly bear on issues discussed under option 4.

Waste Amendments of 1984, wastes to be banned from land disposal could be granted variances or extensions if sufficient alternative treatment, recovery, or disposal capacity were not available.[21]

4. More incineration would take place in land-based facilities closer to human populations, thereby increasing direct human exposure to incinerator emissions. At the same time, the risk of a spill or other adverse impact on the marine environment would not be increased.

5. Prices charged to generators to dispose of at least some incinerable hazardous wastes (e.g., PCBs) would probably rise, because of increased demand on available capacity. This same factor might also increase existing pressures to dispose of hazardous waste illegally.

**Option 2:**

**Halt commercial ocean incineration temporarily, until more research is completed. The research would probably require a few burns at sea to collect data needed to evaluate incinerator performance, to characterize emissions, and to assess environmental impacts.**

**Implications (in addition to those for Option 1)**

1. A climate of extended regulatory uncertainty probably would significantly impede or halt new investment in the ocean incineration industry.

2. Research would probably answer some questions and narrow the overall window of uncertainty. It should be relatively easy, for example, to improve our understanding of the composition of incinerator emissions and at least their initial environmental behavior. Nevertheless, numerous questions, especially those involving the risk of spills or cumulative adverse environmental impacts, would probably only be resolved through experience on a larger scale.

3. If a decision were ultimately made to proceed with ocean incineration, the ensuing program would probably benefit from information gleaned through research. Incorporating such information into a regulatory program during its development would probably be easier than modifying an ongoing program.

4. The question of when *enough* research had been done would have to be faced. Comparable attention to information gaps in other alternatives, including land-based incineration, would be necessary to provide a valid comparative risk assessment. Some level of uncertainty will always remain.

5. Criteria for determining the type and number of ocean research burns to conduct would need to be developed and evaluated. For example, EPA's Ocean Incineration Research Strategy calls for using PCB waste because both the toxicity characteristics and the detection methods for PCBs have been

[21]Sec. 201(h) of the amendments specifies that such variances or extensions may be granted for a maximum of 2 years. The course of action that would ensue after 2 years if alternative capacity were still unavailable is not clear.

well studied. Because typical ocean incineration wastestreams would probably be composed of complex mixtures of many different chemicals, however, the applicability of results from this test burn to real situations would be limited.

6. The question of *who* should do the research would also need to be faced. Widespread public mistrust currently exists as to whether EPA or industry could objectively carry out the research. Addressing this credibility gap or identifying alternative ways to perform the studies or to assure credible results would not be an easy task.

**Option 3:**

**Proceed with a commercial ocean incineration program under the regulatory framework being developed by the Environmental Protection Agency.**

**Option 4:**

**Proceed with a *modified* ocean incineration program that would accomplish one or more of the following:**

**A. include provisions that impart an *interim* status to the program;**
**B. strengthen regulatory requirements where necessary to address areas of deficiency or continuing public concern; and/or**
**C. provide for greater direct involvement by the government in the actual operation of ocean incineration.**

In contrast to the first two options, options 3 and 4 both involve a choice to employ ocean incineration on a routine basis. Options 3 and 4 differ from each other primarily in how much they would dictate or influence the scale of the ocean incineration program. The discussion of these options, therefore, begins below by examining factors that might influence the extent to which ocean incineration would be used. The discussion also explores some of the implications of proceeding with ocean incineration on various scales.

Option 4 goes beyond the status quo approach of option 3, by suggesting several approaches to addressing certain of the key deficiencies or potential uses of ocean incineration that OTA has identified. The discussion considers several possible departures from EPA's proposed program, both to address specific shortcomings and to illustrate the potential for modifying the current approach to using ocean incineration. Most importantly, the discussion suggests certain mechanisms that might help to ensure that any ocean incineration program that developed would be instituted in an *interim* manner, allowing the reliance on ocean incineration to decrease as capacity in better alternatives develops.

### *Determining the Scale of an Ocean Incineration Program*

#### Influences

Although innumerable factors would influence the scale of an ocean incineration program, many could be directly controlled through regulatory or economic measures. Depending on how much control the government ex-

erted, the scope of the program could be tentative or experimental in nature, could evolve in an essentially free market setting, or could entail active government promotion or involvement.

Regardless of the intent and extent of the controls, however, predicting the actual scale of ocean incineration would be difficult. This source of uncertainty would complicate the task of estimating resource allocation and regulatory needs, and of predicting how ocean incineration would affect hazardous waste management in general. Sufficient resources must be available for regulatory and monitoring activities to ensure safe operation and to allow the collection of reliable data on which to base future decisions. Moreover, the question of who should pay for these activities must be addressed.

Four categories of "scaling" factors are discussed below:

1. *Market Factors*: These factors, which could be strongly influenced by regulations or other government actions, include: how much waste generators would have to pay for ocean incineration services compared to how much other alternatives cost; the availability and regional distribution of ocean incineration sites and of port facilities for storage and transfer of wastes; and how much new capital investment would be required to develop such facilities.

   Incinerable liquids with high fuel value (i.e., energy content) exemplify the influence of market factors. Such wastes currently represent a very competitive market, comprised of industrial boilers and furnaces, recovery and recycling operations, and land-based incinerators. The predictable result is that wastes move in the direction of lowest costs to generators (within regulated bounds). The entry of ocean incineration into such a market would result in adjustments based largely on how competitively priced the new services were.
2. *Government Intervention*: Governmental attention could take both regulatory and nonregulatory forms. Regulatory requirements could influence the market for ocean incineration by affecting the quantities and types of waste available for ocean incineration (e.g., limitations on waste composition; requirements to demonstrate a need to incinerate at sea) or the costs of doing business (e.g., requirements for liability and financial responsibility; fees for monitoring and permitting). Nonregulatory influences might include economic incentives or disincentives or direct government support measures (e.g., loan guarantees; taxes assessed on the quantity of waste generated or disposed; government ownership or operation of incineration vessels).

   Broader government regulatory actions influencing hazardous waste management in general could exert significant indirect influence over the use of ocean incineration. Examples of such factors include the extent and schedule of implementation of the 1984 RCRA restrictions on land disposal and the development of siting criteria for disposal facilities.
3. *Public Opposition*: Public opposition has surfaced to all phases of ocean incineration operations: locating port facilities for storing and transferring wastes; transporting wastes over land to port sites; designating sites for ocean incineration; setting requirements for permits and liability;

and regulating the incineration process itself. The public has also been critical of the adequacy of mechanisms for ensuring meaningful public education and participation.

Perhaps most important, the public has questioned whether EPA can objectively develop and administer a regulatory program for ocean incineration. Clearly, additional means of addressing public concerns must be developed as part of any future program.

4. *"Feedback"*: Another factor that would influence the scale of an ocean incineration program would be any response taken to account for new information obtained through experience or monitoring. Such information might relate to accident rates, the relative safety of different technologies, the effectiveness of particular regulatory measures, the results of environmental monitoring, or the program's influence on progress toward implementing measures to reduce waste or developing preferable treatment alternatives.

   Mechanisms would have to be developed for modifying the scale of the program if the data indicated that adjustments were warranted. For example, as capacity in preferable alternatives such as recycling and recovery developed, economic or regulatory measures might be needed to redirect wastes from ocean incineration to these options. Such measures could be particularly important to ensure the *interim* status of the ocean incineration program.

### Specific Approaches

The proposed regulatory framework for ocean incineration contains few provisions that would directly limit the scale of the program. As currently formulated, it could be expected to result in a relatively open-ended (although highly regulated) system, whose size would largely depend on private initiative and investment and on the operation of the market. This approach would be consistent with the current regulatory approach to land-based incineration and certain other hazardous waste technologies.

If interim status were the desired goal, however, Congress and EPA might wish to consider measures for controlling the use of ocean incineration:

**Permit Ocean Incineration Only for Wastes for Which a Need To Incinerate At Sea Can Be Demonstrated.**—The issue of need is closely related to the question of how ocean incineration would affect the use of better waste management or waste reduction alternatives. OTA expects that developing ocean incineration would probably not significantly impede the development and implementation of preferable alternatives. Certain regulatory measures could be applied to users of ocean incineration, however, to ensure that the best available options are used to manage or reduce the generation of incinerable wastes.

Such measures might require a waste generator to demonstrate that ocean incineration would be better than (or at least not inferior to) the other available options. Alternatively, the measures could require the waste generator to demonstrate that no feasible land-based alternatives were available for a particular waste. A third approach would be to use the permitting process

to link use of ocean incineration to compliance with a schedule for achieving particular levels of waste reduction, recovery, or recycling. Mechanisms of this sort, while difficult to implement, could provide concrete means to ensure that ocean incineration was indeed employed in an *interim* manner.

**Direct Certain Wastes Toward or Away From Ocean Incineration.**—OTA's finding that **highly chlorinated wastes** might be more beneficially incinerated at sea than on land suggests the possibility of encouraging or even requiring the use of ocean incineration for such wastes (assuming they meet other applicable criteria). On the other hand, because adequate control over metals would be an essential regulatory element, limiting metals could affect the types of incinerable wastes that qualify as candidates for ocean incineration.

The **energy content** of wastes might also be a factor in determining which wastes would be incinerated at sea. Land-based incineration companies compete for such wastes to use as fuel, and industrial boilers and furnaces can also burn high-energy wastes in order to recover their energy content. If the government were to decide that *public* benefit (as opposed to private economic benefit[22]) was sufficient to justify such uses, then a restriction might be placed on the burning of high-energy wastes at sea.

Finally, considerable attention has focused on using ocean incineration to burn **special wastes**, such as PCBs and DDT. Proponents of ocean incineration cite the properties that render such chemicals so troublesome (environmental persistence, toxicity, ability to bioaccumulate, and resistance to burning) as reasons why these special wastes *should* be burned at sea, whereas opponents of ocean incineration cite the same properties as reasons why such wastes *should not* be burned at sea. The potential use of ocean incineration for such wastes would need further evaluation. Such an evaluation would be particularly important in light of current regulations requiring incineration of PCBs.

Both regulatory and economic approaches to directing particular wastes toward or away from ocean incineration might be warranted if Congress or EPA decided to encourage or restrict the use of ocean incineration for any of the wastes described above. Obviously, because they could significantly affect the overall market for either included or excluded wastes, such measures would therefore need to be assessed from a broad perspective.

**Geographically Restrict the Transportation of Wastes To Be Incinerated At Sea.**—Transporting and importing wastes generated in one area to another area for storage and loading onto an incineration vessel has engendered a significant amount of public concern. These issues have raised questions of *equity* with respect to who should bear the risks and enjoy the benefits of using ocean incineration. Such questions are by no means unique to the issue of ocean incineration.

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[22]Obviously, the private firms involved would experience a savings in fuel costs. This argument has been used by land-based incineration companies in their opposition to ocean incineration. Proponents of ocean incineration claim that the land-based companies are simply wary of more competition, and that the market should decide where such wastes go.

**Figure 3.—Location of the Designated (Gulf of Mexico) and Proposed (North Atlantic) Incineration Sites**

SOURCE: Office of Technology Assessment.

Implementation of geographic limitations on the transportation of wastes for the purpose of incineration at sea might help to address some of the public concern. These limitations might take any of several forms, including specifying a maximum distance for land transport, directing wastes to ports most suitable for handling them, or requiring the use of particular burn sites for particular wastes. In conjunction with designating multiple sites for ocean incineration and with developing port selection criteria, geographic limitations could help to address the equity issue by requiring wastes to be managed near their points of origin.

**Restrict the Number of Operating Permits.**—If the Nation were to proceed with a provisional or experimental program of ocean incineration, Congress or EPA might want to specifically limit the size of the fleet or the number of vessels in operation at any given time. This could be accomplished

by granting permits only to existing vessels or to some predetermined number of vessels. Some observers have called for the development of criteria to allow consideration of a company's compliance record as an integral part of the permitting process. In addition, demonstrating financial responsibility would be a minimum requirement for receiving a permit, although the level and the nature of liability to be required for ocean incineration have yet to be determined.

Using criteria such as these to restrict the number of permits granted would limit the scale of the program and would specifically address key public concerns. However, this approach might severely curtail new investment into ocean incineration and, therefore, could limit expansion of the fleet if that were desired at a later date or hamper research and development aimed at improving existing ocean incineration technology.

**Restrict the Period for Which Permits Are Granted.**—EPA's proposed Ocean Incineration Regulation would grant individual ocean incineration operating permits for 10 years, subject to renewal after 5 years (or more frequently at the request of the Assistant Adminstrator). Critics have raised legitimate questions over whether a 10-year permit length would be appropriate in a new program. To attract private investment, of course, some degree of business certainty and sufficient opportunity for making profits would be necessary.

In any event, determining the appropriate length of permits provides an additional opportunity for controlling the scale of an ocean incineration program, and should be a consideration in resolving the ongoing debate on this issue.

**Provide for the Government To Own or Operate Incineration Vessels.**—This option is arguably the most extreme of those considered, because of its radical departure from the traditional and widespread private approach to hazardous waste management in this country, and the potential conflicts of interest associated with direct entry of the government into such a controversial enterprise.

This approach, however, would provide a very direct mechanism for controlling the scale of an ocean incineration program, in that the government could determine the quantities and types of wastes it would burn in its own ships.[23] Moreover, because government-sponsored ocean incineration could potentially occur in a nonprofit-driven setting, the government could more easily reduce or terminate the program, if and when that were deemed desirable. This approach could very directly and relatively easily ensure that ocean incineration would be viewed and conducted as an *interim* program.

Serious obstacles to government ownership, however, are equally apparent. Perhaps the most troublesome is that it would juxtapose regulatory and promotional roles that many members of the public regard as too close al-

[23]This option is not entirely academic: the government may, in fact, now own two incineration vessels, because of the recent bankruptcy of Tacoma Boatbuilding, Inc., and the subsequent loan default of its subsidiary, At-Sea Incineration, Inc.

ready. Given the already low degree of public confidence that EPA could objectively develop and administer a regulatory program for private ocean incineration, the concept of public ownership may simply be too precarious to be seriously entertained.

## SHAPING AN OCEAN INCINERATION PROGRAM

The fundamental policy issue concerning ocean incineration is whether to proceed with development of a regulatory program. Although this decision will require difficult political judgments, analyzing particular issues from a technical perspective can help clarify the implications of various alternatives and help design ensuing programs, if ocean incineration is allowed. To this end, OTA has identified and analyzed a large number of technical factors that bear directly on such a decision. Several key policy issues have emerged from this analysis, and are briefly introduced below.

### *Regulation of Incinerator Emissions*

**One important policy issue is whether proposed regulations governing incinerator emissions are adequate.** In regulating emissions from ocean incineration, EPA has proposed to extend the approach it originally developed for regulating land-based incineration, which is based primarily on measures of *incinerator* performance.[24] This approach emphasizes the attainment of a particular level of destruction of wastes, as opposed to establishing numeric limitations on each of the many components of the emissions. The basis for this approach lies in the extreme complexity both of the wastes and of the emissions that are generated when hazardous wastes are incinerated. This complexity precludes routine measurement of all components.

To make the tasks of monitoring and regulating incineration manageable, EPA limits the number of compounds to be analyzed to a small set of compounds that is chosen to be as representative of the entire waste as possible. Incinerator performance is then gauged by measuring the destruction efficiency (DE) for these preselected compounds.[25] EPA's proposed reliance on the DE performance standard has been criticized on several bases.

- EPA's definition of DE does not provide an adequate measure of destruction for all components of the waste or for all possible sets of operating conditions.
- Methodologies for sampling emissions and monitoring incinerator performance are not well developed or have not been verified through actual experience.
- Incinerator emissions have been insufficiently characterized and quantified to permit a valid evaluation of the need for specific emission standards, particularly for metals.

[24]EPA has also proposed certain *environmental* performance standards that would indirectly apply to emissions.

[25]For land-based incinerators equipped with air pollution control devices (i.e., scrubbers), the destruction performance standard is actually a destruction *and removal* efficiency (DRE). DRE is measured *after* the operation of scrubbers. In practice, however, EPA has found that DE and DRE are functionally equivalent, because scrubbers are very inefficient at removing the organic substances that are measured in calculating DE or DRE.

- The toxicity of incinerator emissions, particularly with respect to possible long-term impacts, has not been sufficiently examined.
- The identity, origin, and toxicity of products of incomplete combustion (PICs) have been insufficiently studied, precluding an assessment of their significance and of the possible need for regulation.

### *Transportation Risks*

**A second key policy issue concerns the extent and nature of land and marine transportation risks associated with ocean incineration.** The transportation of hazardous waste is regulated under many authorities at the Federal, State, and local levels. For the purpose of regulating ocean incineration, EPA is proposing few specific controls beyond those already generally applicable to incineration vessels and associated waste transportation and transfer activities. The adequacy of such an approach has been questioned and several areas needing additional attention have been identified:

- Applicable regulations under other agencies need to be referenced and applied specifically to ocean incineration.
- Explicit mechanisms are needed to ensure adequate interagency coordination and delegation of authority for enforcement and monitoring.
- Criteria are needed for selecting and designing ports to be used for ocean incineration.
- Contingency plans and emergency response capabilities need to be developed and coordinated.

### *Comparison of Different Ocean Incineration Technologies*

**A third key policy issue concerns the need for a comparative evaluation of different technologies for ocean incineration.** Several different designs exist or have been proposed for incinerator vessels and associated facilities. These designs could differ significantly with respect to safety and performance. A thorough comparative assessment of different designs may be necessary to ensure the use of the best available technology for ocean incineration. In addition, mechanisms for incorporating newly developed alternative or superior design features into the regulatory program must be developed.

### *Equitable Regulation*

**A fourth key policy issue involves equity in the regulation of land-based and ocean incineration.** Because land-based and ocean incineration are regulated under different statutes, numerous differences exist in regulatory requirements and expectations. Many provisions that apply only to one of the technologies, or are more stringent for one or the other, have stirred considerable debate. Often, such provisions are necessary or desirable to account for differences between the technologies in, for example, the kinds of risks they pose or where they are used.

Given such differences, simply adopting identical sets of regulatory requirements is not likely to accomplish equitable regulation of land-based and ocean incineration. The technical and nontechnical bases for any differential regu-

lations, however, should be subjected to thorough scrutiny and made as explicit and open to review as possible.

### *Public Involvement*

**A fifth key policy issue is whether public involvement in decisions regarding ocean incineration is adequate.** Public opposition to ocean incineration has arguably been the major impediment to development of a regulatory program. At the same time, public involvement has played a substantial role in broadening the scope of the debate over ocean incineration to include consideration of the need to develop a national strategy for managing hazardous wastes.

The nature and extent of public opposition to ocean incineration suggests that available mechanisms for involving the public in the decisionmaking process are woefully inadequate. Although this problem is by no means confined to the subject of ocean incineration, additional mechanisms aimed at ensuring and encouraging meaningful public participation and education are essential to any future regulatory program for ocean incineration. In addition, if any ocean incineration program is to go forward, specific steps must be taken to address and resolve outstanding public concerns surrounding ocean incineration.

### *The Effect of Ocean Incineration on the Development of Better Alternatives*

**A sixth key policy issue is how an ocean incineration program would affect the development and implementation of environmentally preferable waste treatment, recovery, and reduction practices.** A major point of contention has been whether ocean incineration would undermine existing incentives for using and developing better practices and technologies for hazardous waste management. Although OTA's analysis suggests that such an effect is likely to be limited, prudence may dictate taking steps to ensure that waste reduction is implemented wherever possible and that the remaining incinerable wastes are, in fact, directed toward the best available management practices. To this end, certain policy directives or regulatory requirements, specifically applying to users of ocean incineration, might be desirable. Particularly deserving of serious attention are measures that would ensure and increase the *accountability* of waste generators that choose to utilize ocean incineration. Other regulatory and economic means of affecting the role that ocean incineration plays in hazardous waste management may warrant congressional action.

### *Unresolved Questions*

**A seventh key policy issue concerns the seriousness of unresolved questions about the operation and impacts of ocean incineration.** Significant debate centers on whether enough information is currently available to allow an informed decision on whether and, if so, how to proceed with a program for ocean incineration. Although most observers acknowledge that many un-

resolved questions remain, consensus is lacking on which questions, if any, need to be answered before ocean incineration can be permitted and on what means should be used to answer such questions.

Many of the unresolved questions about ocean incineration apply equally to already permitted activities, such as land-based incineration. Consequently, questions arise regarding whether, how much, and when research should be done on these alternatives, and how such research should relate to that required for ocean incineration.

**NOTE: Copies of the full report "Ocean Incineration: Its Role in Managing Hazardous Waste" can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, GPO stock No. 052-003-01046-1.**

# Assessments in Progress as of August 1986

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Technology, Public Policy, and the Changing Nature of Federal Information Dissemination
Wastes in Marine Environments
Technologies To Control Illegal Drug Traffic
Technologies for Exploring and Developing Exclusive U.S. Economic Zones
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Technology and the American Economic Transition
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Magnetic Fusion Research and Development
Competitiveness of Domestic Copper
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Serious Reduction of Hazardous Waste
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Strategic Defense Initiative: Survivability and Software
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